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<p>(21) International Application Number: PCT/US99/30817</p> <p>(22) International Filing Date: 23 December 1999 (23.12.99)</p> <p>(30) Priority Data: 60/114,260 30 December 1998 (30.12.98) US 09/471,044 22 December 1999 (22.12.99) US </p> <p>(71) Applicant: INTERNATIONAL PAPER COMPANY [US/US]; Two Manhattanville Road, Purchase, NY 10577 (US).</p> <p>(72) Inventors: VEVERKA, Peter, J.; 2850 Route 94, Washingtonville, NY 10992 (US). LYNE, Bruce; 112 Turtle Point Road, Tuxedo Park, NY 10987 (US). CHANG, Chialu; 66A Van Wyk Road, Lake Hiawatha, NJ 07034 (US). HILDEN, Gert; Schutzheider Weg 2, D-51465 Bergisch Gladbach (DE).</p> <p>(74) Agent: BROITMAN, Joshua, S.; Ostrager Chong Flaherty & Onofrio, P.C., 300 Park Avenue, New York, NY 10022-7402 (US).</p>		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
<p>Published With international search report.</p> <p>(54) Title: MULTI-LAYER COATED COPY PAPER FOR IMPROVED PRINTING AND PERFORMANCE</p> <ul style="list-style-type: none"> • BRIGHTNESS • GLOSS • SMOOTHNESS • SLIGHT MACRO ROUGHNESS • TONER/INK HOLDOUT • TONER ADHESION • CONDUCTIVITY <ul style="list-style-type: none"> • THERMAL INSULATION • POROSITY/BULK • OPACITY • BRIGHTNESS • CONDUCTIVITY <ul style="list-style-type: none"> • STIFFNESS • LOW MOISTURE • GOOD FORMATION • MODERATE TENSILE • MODERATE REFINING • NO MECHANICAL FIBERS <p>(57) Abstract</p> <p>A multi-layer coated copy paper has an intermediate basecoat layer between the base paper layer and outer topcoat layer containing from 10% to 70% ground calcium carbonate (CaCO_3), from 90% to 30% fully or partially calcined clay ($\text{Si}_4\text{Al}_4\text{O}_{10}(\text{OH})_n$, where $n < 8$), and from 0% to 30% satin white ($3\text{CaO}-\text{Al}_2\text{O}_3-3\text{CaSO}_4-31\text{H}_2\text{O}$), with a binder.</p>		

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**MULTI-LAYER COATED COPY PAPER FOR
IMPROVED PRINTING AND PERFORMANCE**

Technical Field

5 This invention generally relates to multi-layer coated copy paper, and more particularly, to paper having thermally insulating basecoat layers between a basecoat paper layer and outer topcoat layers.

Background of Invention

10 Previous layered structures for coated paper have used paper coating compositions of coating grade pigments such as kaolin clay, satin white, calcium carbonate, titanium dioxide, hydrated alumina, barium sulphate, limestone, etc., together with adhesives or binders such as latex and starch adhesives. The coating layers may be applied by any of a variety of commonly used coating techniques. The coated paper may be finished by calendering to form a high-gloss paper. Examples of such coated paper products are described in U.S. Patent 15 3,682,733 to Smit, and U.S. Patent 4,154,899 to Hershey.

20 However, such coated papers were not specifically designed to function in color or monochrome copiers. While the use of coating layers to prevent copy blistering has been known, coated or layered paper structures have not 25 been specifically designed to optimize the print quality of toner in copiers, to reduce the amount of power required for toner copying, and possibly to lower the amount of toner usage required for printing with comparable copy quality.

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Summary of Invention

In accordance with the present invention, a multi-layer coated copy paper comprises a base paper layer of paper pulp, an outer topcoat layer including mineral 5 pigments and fine clay, with a binder, and an intermediate basecoat layer between the base paper layer and outer topcoat layer containing from 10% to 70% ground calcium carbonate (CaCO_3), from 90% to 30% fully or partially calcined clay ($\text{Si}_4\text{Al}_4\text{O}_{10}(\text{OH})_n$, where $n < 8$), and from 0% to 30% 10 satin white ($3\text{CaO}\text{-}\text{Al}_2\text{O}_3\text{-}3\text{CaSO}_4\text{-}31\text{H}_2\text{O}$), with a binder. The coating weight of the intermediate basecoat layer is preferably from 10 to 14 gsm. The basecoat and topcoat layers may be formed on one or both sides of the base paper layer.

15 Other objects, features, and advantages of the present invention will be explained in the following detailed description of the invention having reference to the appended drawings.

Brief Description of Drawings

20 FIG. 1 shows in cross-section a multi-layer coated copy paper structure in accordance with the invention.

25 FIG. 2 is a sample graph showing surface temperatures as a function of time of three commercial samples and an improvement sample during a ten-copy cycle.

FIG. 3 shows a comparison between a commercial sample and an improvement sample for the numerical integral of the area under the temperature vs. time curve.

30 FIG. 4 shows the relationship between the numerical integral of temperature over time with the weight

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% of calcined clay in the total sheet.

FIG. 5 is a graph comparing the heat diffusivity of the basecoat for different levels of calcined clay and different types (fine or coarse) of ground calcium carbonate.

FIGS. 6A - 6D illustrate print gloss as a function of print density for high and low speed copying on the improved paper.

Detailed Description of Invention

Referring to FIG. 1, a multi-layer coated copy paper in accordance with the invention has a base paper layer ("Basepaper") of paper pulp, an outer topcoat layer ("Topcoat") of mineral pigments and fine clay together with a binder, and an intermediate base coating layer ("Basecoat") between the base paper layer and outer topcoat layer. In the figure, a two-sided copy paper structure is shown in which Topcoat and Basecoat layers are provided on both sides of the Basepaper layer. The upper side of the Basepaper layer is indicated as the "felt side", and the lower side is indicated as the "wire side", referring to the sides of the paper web between the forming wire it is carried on and the felt it is pressed with during the paper forming process. In use for copying, the felt side of the coated paper is the preferred side to be copied on (instructions are commonly marked on paper reams to "Copy this Side First"), as the felt side has the better gloss and finish characteristics. Therefore, a toner area ("Toner") is indicated as formed on the felt side of the coated paper. However, the wire side of the coated paper may also be used for copying as well.

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The felt-side Topcoat is indicated as having a thickness $y(1)$, felt-side Basecoat thickness $x(1)$, Basepaper thickness z , wire-side Basecoat thickness $x(2)$, and wire-side Topcoat thickness $y(1)$. In general, the
5 relative thicknesses of the preferred multi-layer coated copy paper are as follows:

$$\begin{aligned}y(1) &\approx y(2) \\x(1) &\approx x(2) \\z &> x(1) > y(1)\end{aligned}$$

10 The Basecoat is formed with a combination of bulky minerals to give it the preferred properties: thermal insulation; porosity/bulk; opacity; brightness; and conductivity. The following combination and ranges have been found to produce optimal results:

- 15 (a) 10% to 70% ground calcium carbonate (CaCO_3); and
(b) 90% to 30% fully calcined clay ($\text{Si}_4\text{Al}_4\text{O}_{10}(\text{OH})_n$, where $n<8$), and/or
(c) 90% to 30% partially calcined clay; and
(d) 0% to 30% satin white ($3\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot3\text{CaSO}_4\cdot31\text{H}_2\text{O}$).

20 The ratio of mineral pigments (b) and (c) to ingredient (a) in the Basecoat layer is preferably in the range of from 9:1 to 1:1.8, with the exact ratio dependent on the thermal insulating requirements for the Basecoat layer as a function of its basis weight. By using one-
25 dimensional conductive heat transfer models, the ratios of ingredients in the Basecoat layer can be optimized so that the resulting thermal insulation properties allow the

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fusing process to be independent of basis weight.

In the manufacturing process, the base coating may be formed by a contour type of coating device, such as air knife, curtain coater, or metering size press, or by a 5 blade type of coating device, such as flooded nip, short dwell time applicator, jet coater, or puddle coater. The coating weight of the Basecoat layer is preferably from 10 to 14 gsm. The basecoat and topcoat layers may be formed on one or both sides of the base paper layer.

10 The Basepaper can be made of any suitable paper pulp composition with the desired properties: stiffness; low moisture; good formation; moderate tensile strength; moderate refining; and no mechanical fibers. Preferably, it is either fully bleached chemical pulp, or has a 15 fraction up to 50% of deinked pulp.

The Topcoat is formed with a combination of mineral pigments and fine clay with a binder, to give it the preferred properties: brightness; gloss; smoothness; slight macro roughness; toner/ink holdout; toner adhesion; 20 and conductivity. Optimal results are found to be achieved with a combination of the above-mentioned mineral pigments (a) to (d), and the following additional ingredient: (e) 0% to 40% fine clay or platy clay ($\text{Si}_4\text{Al}_4\text{O}_{10}(\text{OH})_n$, where n=8).

25 The ingredients of the Topcoat and Basecoat are mixed with a binder to "glue" them together, preferably either:

- (f) 8% to 20% (of total weight) synthetic latex; or
- (g) 0.5% to 5% polyvinyl alcohol (PVOH or PVA).

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Other minor additives, constituting less than 1% by weight, include: brightening agents; lubricants; synthetic thickeners; and defoaming agents.

Two commercial samples (Enso 4CC and Xero Laser
5 Gloss) and twenty-one improvement samples (13 in BASF Trial #1, 8 in BASF Trial #2) were temperature-monitored on a Xerox DC40 copier as a function of time during a ten-copy cycle. The samples were preconditioned at standard TAPPI conditions for at least 24 hours prior to testing. A
10 Minolta/Land Cyclops Compac 3 infrared (IR) camera was used with a Minolta/Land Cyclops DP-A strip chart recorder to monitor the surface temperature as each copy exited the Xerox DC40 copier onto a stacking tray. Extreme care was taken to maintain the camera angle and distance to the
15 sample during the experiment. Data acquisition was handled by a Toshiba T6600C computer interfaced with the strip chart recorder, running at 4 Hz acquisition speed. The approach was semi-quantitative in that the exact heat transfer mechanism (conductive and convective cooling) was
20 measured post facto. It was also noted that slight differences ($\pm 0.5\%$) in the moisture content in the paper could affect the surface temperature measurement.

In the Warm-up mode, the fuser roll temperature was controlled to 180°C (356°F) and the pressure roll to 165°C (329°F). The fuser control circuit normally switches to the Run mode when the first Registration Release Signal is generated. While in the Run mode, the fuser roll temperature was controlled to 160°C (320°F) and the pressure roll to 165°C (329°F). The first three copies from the
25 30 Xerox DC40 copier generally are hotter as the copier switches from Warm-up mode to Run mode.

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The commercial samples Enso 4CC (130 gsm) and Xero Laser Gloss (120 gsm) do not have an insulating basecoat layer between the base paper layer and the topcoat layer. The 21 improvement samples had a basecoat layer of varying composition. The component ingredients for the basecoat layer were: Ansilex 93 (TM) calcined clay, obtained from Engelhard Corporation, located in Iselin, New Jersey (USA); Hydrocarb-CC (TM) calcium carbonate (fine pore size diameter), obtained from OMHY PLÜSS-STAUFER AG, in Oftringen, Switzerland (designated HC-CC); Hydrocarb-60 (TM) calcium carbonate (coarser pore size diameter); Flash calcined clay sold under the product name 97-7000, from ECC International located in Cornwall, England; and satin white (SW) or calcium sulfoaluminate manufactured under a proprietary process at Zanders Feinpapier AG (Bergish Gladbach, Germany). A commercial satin white product of similar composition is Suprasmit Satin White sold by Suprasmit B.V. located in Maastricht, Netherlands. The compositions of the samples were:

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Improvement Sample		Basecoat Composition	Basecoat Weight (gsm/side)	Total Weight (gsm)
Trial #1	A1	60/40 ECCI 97-7000/HC-CC	14	135
	A4	60/40 ECCI 97-7000/HC-CC	14	135
	D1	90/10 Ansilex/HC-CC	14	135
	D2	90/10 Ansilex/HC-CC	14	135
	D3	90/10 Ansilex/HC-CC	14	135
	D4	90/10 Ansilex/HC-CC	14	135
	D5	90/10 Ansilex/HC-CC	14	135
	D6	90/10 Ansilex/HC-CC	14	135
	D7	90/10 Ansilex/HC-CC	14	135
	D8	90/10 Ansilex/HC-CC	14	135
	E1	60/40 Ansilex/HC-CC	14	135
	F1	60/25/15 Ansilex/HC-CC/SW	14	135
	D-Satin	60/25/15 Ansilex/HC-CC/SW	14	115
Trial # 2	A1(2)	50/50 Ansilex/HC-60	13	135
	A3(2)	50/50 Ansilex/HC-60	13	135
	A4(2)	50/50 Ansilex/HC-60	13	135
	B1(2)	35/65 Ansilex/HC-60	13	135
	B3(2)	35/65 Ansilex/HC-60	13	135
	B4(2)	35/65 Ansilex/HC-60	13	135
	C1(2)	50/50 Ansilex/HC-CC	13	135
	C2(2)	50/50 Ansilex/HC-CC	13	135

5 As shown in FIG. 2, the output data for the three commercial samples were compared to improvement trial sample D1, which contained 90 parts of Ansilex 93 and 10 parts Hydrocarb-CC as the composition of the basecoat. The samples had total basis weights ranging from 120 gsm to 135
10 gsm, for comparison in the heavy-weight (105-210 gsm)

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copying mode. The results showed that the improvement sample with the thermally insulating basecoat layer had maximum surface temperatures up to 10°C (18°F) cooler than the commercial products. This indicates that the improvement sample would have reduced blocking because, with lower sheet temperatures in the stacking tray, the toner would drop below its melting temperature T_g more quickly. The power requirements for copying are also reduced by as much as 20%, thereby allowing increased throughput (copies/minute). An alternative method would be to measure the current draw (amperage) on the fuser roll required to keep the roll surface at the setpoint.

As shown in FIG. 3, a comparison was made between the Enso 4CC sample and the D1 improvement sample for the numerical integral of the area under the temperature vs. time curve. Only the last five temperature peaks (peak #5 to #9) were integrated using the minimum temperature as the lower integrating point. The integral can be expressed as:

$$A = \int T(t) dt \approx \sum (T_i \Delta t - T_{min} \Delta t)$$

The results show that the numerical integral for the Enso 4CC sample was 777.6°C-sec., while that of the improvement sample D1 was only 629.7°C-sec., a decrease of about 19%. This indicates that the heat from the fusing rolls remains at the outer surface of the coated sheet due to the insulating basecoat layer.

Output data from the comparative tests for all 21 improvement samples are summarized in Table I. The first column lists the sample names. The second column records the numerical integral of the area under the temperature

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vs. time curve for each sample. The third column records the average deviation in the values measured for each sample. The fourth, fifth, and sixth columns record the average temperature, maximum temperature, and minimum 5 temperature in °C for each sample. The seventh column records the difference in the numerical integral for each sample as compared to the Enso 4CC sample. In the last three columns, relevant indicators for print performance are given. The optical density and the gloss were measured 10 on the 100% black print area. The glossmeter was a Gadco Statistical Novogloss meter aimed at a 20° angle to the plane of the paper (i.e., 70° to the surface normal). The lower angle allowed better discrimination of the print quality. The normalized ratio of gloss to density was also 15 computed.

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TABLE I

Comparison of Trial and Commercial Samples For Thermal Performance
on Xerox DC40 High Speed Color Copier - Heavy Weight Copy Mode

		Temperature Data								
	Numerical Integral (°C x sec)	Average Deviation (°C)	Avg. (°C)	Max. (°C)	Min. (°C)	%Diff. for Num. Int vs. 4CC	Density	Gloss 20°	Gloss/Density	
Commercial Samples										
5	Enso 4CC	777.6	5.9	63.5	78.8	53.8		1.69	19.8	11.7
	Xerox	715.1	5.1	63.3	76.1	54.4	-8.0%	1.72	10.7	6.2
BASF Trial #1										
10	A1	602.6	4.6	57.9	71	50.4	-22.5%	1.65	18.4	11.1
	A4	558.3	4.1	56.8	67.5	49.9	-28.2%	1.58	14.4	9.1
	D1	629.7	4.6	58.8	70.2	51	-19.0%	1.64	28.6	17.5
	D2	580.1	4.5	56.7	69.9	49.5	-25.4%	1.65	20.1	12.1
	D3	590.3	4.3	58.2	70.5	50.9	-24.1%	1.59	16	10.1
	D4	583.4	4.2	55	67	47.8	-25.0%	1.61	17.3	10.7
15	D5	631.6	4.7	58.3	71.9	50.5	-18.8%	1.62	26.3	16.2
	D6	644	4.2	56.3	68.3	48.3	-17.2%	1.64	19.7	12
	D7	559.7	4.3	56.2	68.2	49.2	-28.0%	1.61	18.9	11.7
	D8	647.1	4.2	55.3	67.3	47.3	-16.8%	1.6	17.7	11.1
20	E1	613.8	4.5	59	70.9	51.4	-21.1%	1.66	23.8	14.3
	F1	747.3	4.9	58.1	71.2	48.8	-3.9%	1.64	15.2	9.3
	D-SATIN	641.2	4.7	57.6	69.3	49.7	-17.5%	1.62	35.2	21.7
BASF Trial #2										
25	A1(2)	672.7	4.9	60.6	73.4	52.2	-13.5%	1.66	18.7	11.2
	A3(2)	737.2	4.9	59.6	73.1	50.4	-5.2%	1.63	17.1	10.5
	A4(2)	630.7	4.8	56.6	70.2	48.8	-18.9%	1.66	23.3	14.1
	B1(2)	708.9	5.2	61.4	74.1	52.6	-8.8%	1.73	33.2	19.2
	B3(2)	748.9	5.1	58	71.6	48.7	-3.7%	1.66	11.9	7.2
30	B4(2)	621	4.8	56.5	70	48.8	-20.1%	1.66	19.6	11.8
	C1(2)	631.6	5.2	61	74.6	53.2	-18.8%	1.68	24.6	14.7
	C2(2)	719.2	5.1	60.1	73.2	51.2	-7.5%	1.68	30.2	18

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The results as summarized in Table I showed that the average surface temperatures of the Trial #1 samples ranged from about 4°C to 8.5°C cooler than the commercial samples. Maximum surface temperatures ranged 5 from 4°C to 12.5°C cooler. The numerical integrals of the temperature vs. surface curves (except for the F1 sample) ranged from 17% to 28% lower than the Enso 4CC sample. Gloss/density ratios were up to 50% higher for the improvement samples.

10 The average surface temperatures of the Trial #2 samples (having lower proportions of calcined clay than the Trial #1 samples) ranged from about 2.5°C to 7°C cooler than the commercial samples. Maximum surface temperatures ranged from 1.5°C to 10°C cooler. The 15 numerical integrals of the temperature vs. surface curves ranged from 4% to 20% lower than the Enso 4CC sample. Gloss/density ratios were up to 80% higher for the improvement samples.

20 As between improvement samples, those that contained higher proportions of calcined clay in the basecoat exhibited better thermal performance and improved print gloss. The data suggests an optimum composition for the basecoat of 60 to 65 parts Ansilex-93 calcined clay and 35 to 40 parts Hydrocarb-CC calcium 25 carbonate. The type of calcium carbonate used does seem to have some effect on the performance of the calcined clay, with Hydrocarb-CC being preferred. The differences in print gloss varied widely, but overall were not as high as might be expected. The combination of lower 30 total weight (by 20 gsm), combined with higher insulating effect on the surface, gave the highest gloss for the

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samples.

The topcoat composition appeared to affect the thermal insulating properties as well as the coating porosity. To eliminate the topcoat as a factor, the 5 samples A1, E1, D1, A1(2), B1(2), AND C1(2) having similar topcoat compositions were compared for numerical integral values ($^{\circ}\text{C}\cdot\text{sec.}$) and integral values x % moisture ($^{\circ}\text{C}\cdot\text{sec.}\%$ Moisture) as a function of weight % of calcined clay in the total sheet. As illustrated in FIG. 10 4, a strong relationship was found to exist between lower numerical integral of temperature over time with greater weight % of calcined clay in the total sheet up to 10.5% (equal to about 60 parts of calcined clay). For higher weight %, it is believed that only a small difference 15 (about 10%) in the internal coating intrusion volume is contributed for proportions of calcined clay above 60 parts up to 90 parts. Thus, there appears to be no strong incentive for increasing the calcined clay level above 60-65 parts. This is also positive for runnability 20 and better cost performance.

A representative group of samples was also tested using a Holometrix Microflash unit, obtained from Holometrix Corp., Bedford, Massachusetts. Heat diffusivity (α) in cm^2/sec was calculated based on bulk 25 density (ρ), specific heat (C_p), and conductivity (λ), by the following equation:

$$\alpha = \lambda / \rho C_p$$

In order to calculate how the diffusivity for each of the components contributes to the final diffusivity, a weight

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fraction (x) summation relation is used:

$$\alpha_{\text{total}} = \sum \alpha_i x_i = \alpha_{\text{paper}} x_{\text{paper}} + \alpha_{\text{basecoat}} x_{\text{basecoat}}$$

Results of heat diffusivity measurements for the different components of the basepaper layer, basecoat
 5 (precoat) layer, and topcoat layer are summarized in Table II (values are multiplied by 100,000 to display the data more easily).

TABLE II
 Heat Diffusivity of Individual
 Components in the Precoat and Topcoat

Component	Heat Diffusivity x 10 ⁵ (cm ² /sec)
Uncalendered Paper - base 81-84 gsm, 14% filler	163
Calcined Clay - Ansilex-93	16.1
GCC - Hydrocarb-CC	73.3
GCC - Hydrocarb-60	83.8
Binder = Styronol LD615/PVA	106.5
TopCoat = Hydrocarb-90/UltraWhite 90	85-102

In general, the lower heat diffusivity indicates better thermal insulating properties. The results indicate that the calcined clay component (Ansilex 93) was the most important contributor to lower heat diffusivity, and that the Hydrocarb-CC fine ground calcium carbonate had better values than the Hydrocarb-60 coarse ground calcium carbonate.
 20
 25

Results of heat diffusivity measurements for

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different levels of calcined clay in the basecoat layer are summarized in Table III (values are multiplied by 100,000). The results indicate that higher levels of calcined clay produced lower coating heat diffusivity. The negative value for the coating sample F1 was believed to be due to crystalline water in the satin white becoming vaporized at 105°C.

10 TABLE III

Heat Diffusivity with Calcined Clay Level

15 Paper Diffusivity (cm²/sec) x 100,000 163

Sample	Total (gsm)	Paper (gsm)	Coating (gsm)	Basecoat Composition	Total Diffusivity	Coating Diffusivity
D1	105.5	81.7	23.8	90/10 Ansilex/HC-CC	133	30.02
E1	108.5	83	25.5	60/40 Ansilex/HC-CC	135	43.86
C1(2)	105.8	83.4	22.4	50/50 Ansilex/HC-CC	139	49.64
A1(2)	107.9	82.7	25.2	50/50 Ansilex/HC-60	139	60.24
B1(2)	109.7	82.7	27	35/65 Ansilex/HC-60	130	28.92
F1	104.7	83.3	21.4	60/25/15 Ansilex/HC-CC/Satin White	128	-8.24

10 In FIG. 5, the heat diffusivity of the basecoat composed of 40/60 Ansilex-93/Hydrocarb-CC was compared with 40/60 Ansilex-93/Hydrocarb-60, and also to Ansilex-93/Hydrocarb-CC at 0.5 (50 parts) and 0.75 (75 parts) mass fractions.

15 The overall results indicate that the basecoat composition has lower heat diffusivity (better thermal insulation) at higher mass fractions of the calcined clay and is more pronounced with fine ground calcium carbonate. As indicated in FIGS. 4 and 5 and Tables II and III, the proportion of calcined clay (a higher cost component) in the basecoat can be optimized with

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insulating properties in the range of 60 to 65 parts calcined clay with 40 to 35 parts fine ground calcium carbonate (a lower cost component).

No definite relationship was evidenced between
5 thermal insulation properties and print quality (Print
Gloss 20° / Density). Better print performance is
influenced by lower values of the numerical integral of
temperature vs. time and moisture. As indicated in Table
I, significantly higher print performance can also be
10 obtained with satin white in the basecoat. Small amounts
of satin white may be added to improve print performance
without adversely impacting the thermal insulation
properties of the predominant calcined clay and calcium
carbonate combination.

15 Copying speed tests were also conducted to
demonstrate that the multi-layer coated copy paper
allowing for toner fusing with less energy input will
promote greater throughput (copies/minute) with both
standard and heavier paper weight grades. The tests were
20 conducted on the Xerox DocuColor 40 (DC40) copier with
135 gsm samples in the normal simplex mode at 40
copies/minute and in the heavyweight simplex mode at 20
copies/minute. Two samples 404 and 405 were tested at
varying print density in both normal (high speed) and
25 heavyweight (slow speed) modes. The samples had the same
topcoat composition (10 gsm) but different basecoat
compositions (14 gsm). Sample 404's basecoat was 50/50
Ansilex-93 calcined clay and calcium carbonate. Sample
405's basecoat was 50/50 flash dehydroxylated calcined
30 clay (more internal air voids, lower bulk density) with
calcium carbonate. The remainder of the basecoat

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consisted of polyvinyl alcohol (PVOH), latex binder, optical brightener, and minor additives which did not affect the thermal properties of the coating.

In FIGS. 6A - 6D, the print gloss is measured
5 as a function of print density. The print density is proportional to the quantity /thickness of toner fused to the coated paper surface, and was altered by varying print darkness from the "light" setting to the "dark" setting. Comparing FIGS. 6A and 6C (high speed mode),
10 there was a large variation in print gloss as the print density was changed. This was in contrast to FIGS. 6B and 6D (slow speed mode) where the response was flat. Most important was that at equal density (ca. 1.6) there
15 is only a 45-48% loss in print gloss. Print gloss measurements with the 20-degree glossmeter were much more sensitive to changes in the surface reflectance and smoothness than with a 75-degree glossmeter (more representative of the normal viewing angle to the sheet). A difference of 15-16% in 20-degree measured print gloss
20 is equivalent to only 1-2% in 75-degree measured print gloss.

Thus, the print quality of the multi-layer coated copy paper was within an acceptable range running in the high speed mode and the low speed mode. The
25 results support the conclusion that the thermal properties of the improvement product allow acceptable print quality to be obtained even at higher throughput rates. Toner adhesion was also found to be equivalent for the high and low speed modes. It is believed that,
30 due to the insulation properties of the basecoat, the thermal energy from the fusing rolls remain sufficiently

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on the sheet surface to promote melting and fusing of the toner so that it adheres to the coated paper surface.

In summary, the use of a thermally insulating basecoat layer between the base paper layer and the top 5 coat layer in coated copy paper promotes faster copying with heavier papers, avoids "blocking" in sheet stacking, better print quality, and eliminates blistering of paper as compared with commercially available coated papers lacking the basecoat layer. The basecoat layer acts as a 10 thermally insulating layer which keeps residual heat from toner fusing near the topcoat layers and away from penetrating into the inner layers. This enables toner fusing with less energy input, which will allow greater throughput (copies/minute) with both standard and heavier 15 paper weight grades. It also allows the residual heat to diffuse more quickly and prevents "blocking", the condition in which residual heat keeps the toner on the paper surface so hot after printing that it remains tacky when the papers are stacked in the output tray such that 20 they might stick together or smear the toner.

The benefits of increased throughput (copies/minute) and elimination of blocking can be extended to sheeted paper as well as paper running through the copier as a continuous web. The multi-layered product also provides approximately 10% higher 25 sheet bulk and stiffness due to the lower nip loading required for sheet finishing during the gloss calendering process. The higher paper stiffness will improve runnability during paper feeding, transporting, and 30 duplexing in both monochrome and color copiers, especially at higher feed rates (copies/minute).

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The multi-layer coated copy paper also prevents the fusing process from transmitting excess heat into the base paper, thereby maintaining a higher temperature for a given energy input near the surface during toner fusing. This results in better print characteristics, measured in terms of print gloss and density. It also allows higher basis weight paper grades to be run through the copier at higher throughput. Normally, above a certain basis weight, the fuser section has to be slowed down to 50% of its original speed to obtain acceptable print quality. The base coating layer also effectively eliminates the common blistering problems associated with higher grammage coated color copy paper. Earlier attempts to manipulate the copier paper performance by lowering the residual moisture in the paper were not completely successful, as they had the negative effect of increasing the paper surface resistivity, which impacts retention of the corotron charge and toner transfer.

It will be apparent to persons skilled in this field that many modifications and variations may be devised given the above description of the principles of the invention. It is intended that all such modifications and variations be considered as within the spirit and scope of this invention, as it is defined in the following claims.

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WE CLAIM:

1. A multi-layer coated copy paper comprising:
5 (a) a base paper layer of paper pulp; (b) an outer topcoat layer including mineral pigments and fine clay,
with a binder; and (c) an intermediate basecoat layer
between the base paper layer and outer topcoat layer
containing from 10% to 70% ground calcium carbonate
(CaCO_3), from 90% to 30% fully or partially calcined clay
($\text{Si}_4\text{Al}_4\text{O}_{10}(\text{OH})_n$, where $n < 8$), and from 0% to 30% satin white
10 ($3\text{CaO}\text{-}\text{Al}_2\text{O}_3\text{-}3\text{CaSO}_4\text{-}31\text{H}_2\text{O}$), with a binder.

2. A multi-layer coated copy paper according
to Claim 1, wherein the basecoat layer is composed of 60
to 65 parts calcined clay and 40 to 35 parts calcium
carbonate.

15 3. A multi-layer coated copy paper according
to Claim 1, wherein the basecoat layer has a basis weight
from 7 to 14 gsm.

20 4. A multi-layer coated copy paper according
to Claim 1, wherein basecoat and topcoat layers are
formed on both sides of the base paper layer.

5. A multi-layer coated copy paper according
to Claim 1, wherein the basecoat layer includes fully
calcined clay.

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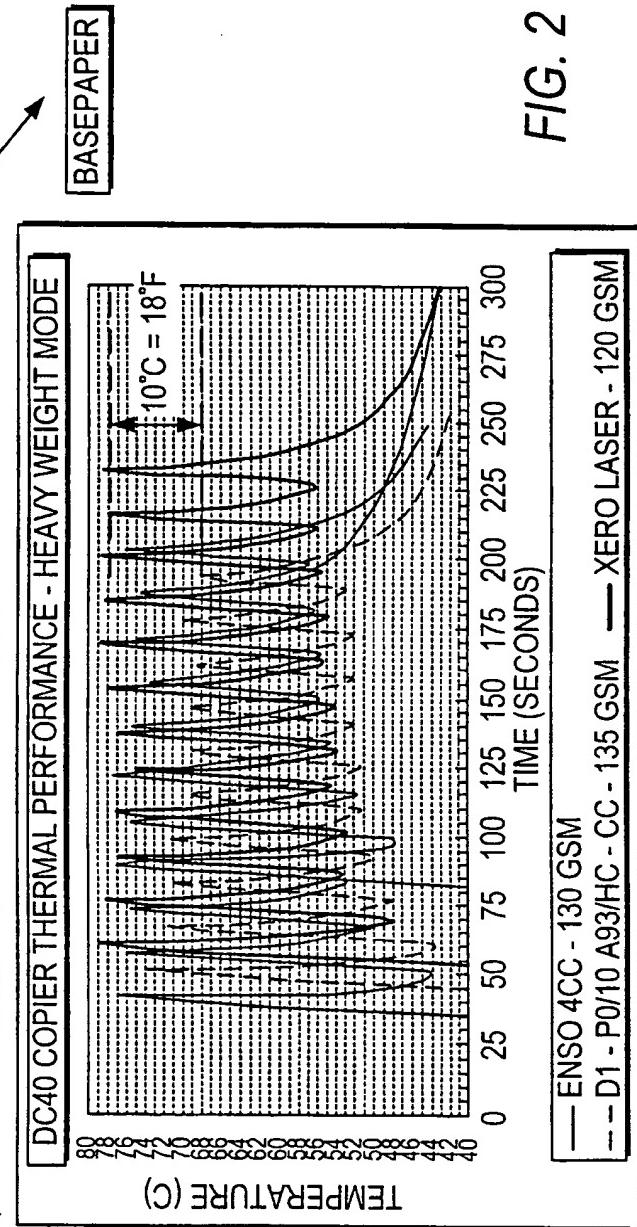
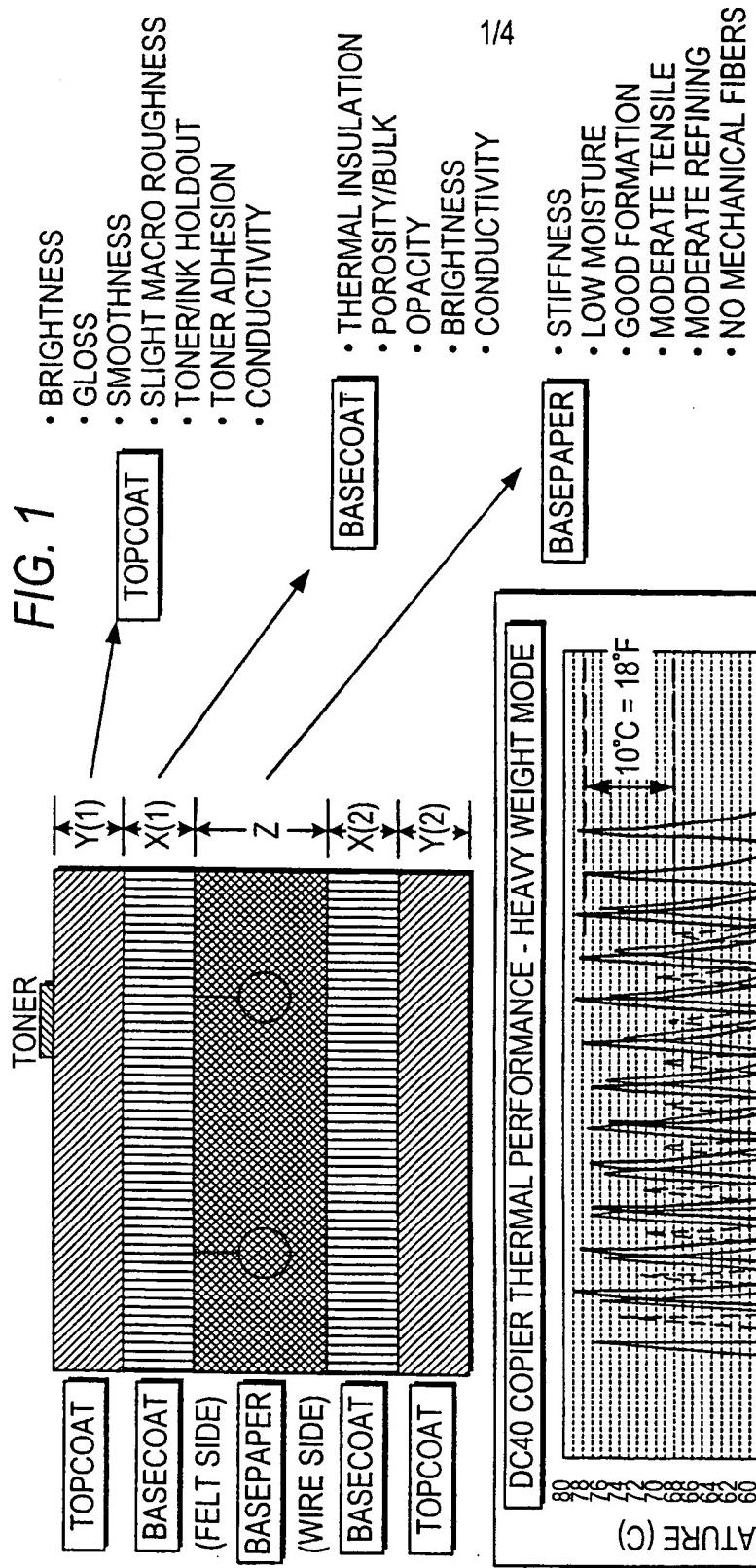
6. A multi-layer coated copy paper according to Claim 1, wherein the basecoat layer includes partially (flash dehydroxylated) calcined clay.

5 7. A multi-layer coated copy paper according to Claim 1, wherein the basecoat layer includes fine ground calcium carbonate.

8. A multi-layer coated copy paper according to Claim 1, wherein the basecoat layer includes coarse ground calcium carbonate.

10 9. A multi-layer coated copy paper according to Claim 1, wherein the basecoat layer includes about 15 parts satin white.

15 10. A multi-layer coated copy paper according to Claim 1, wherein the basecoat layer includes a binder consisting of ingredients selected from the group of synthetic latex and polyvinyl alcohol.



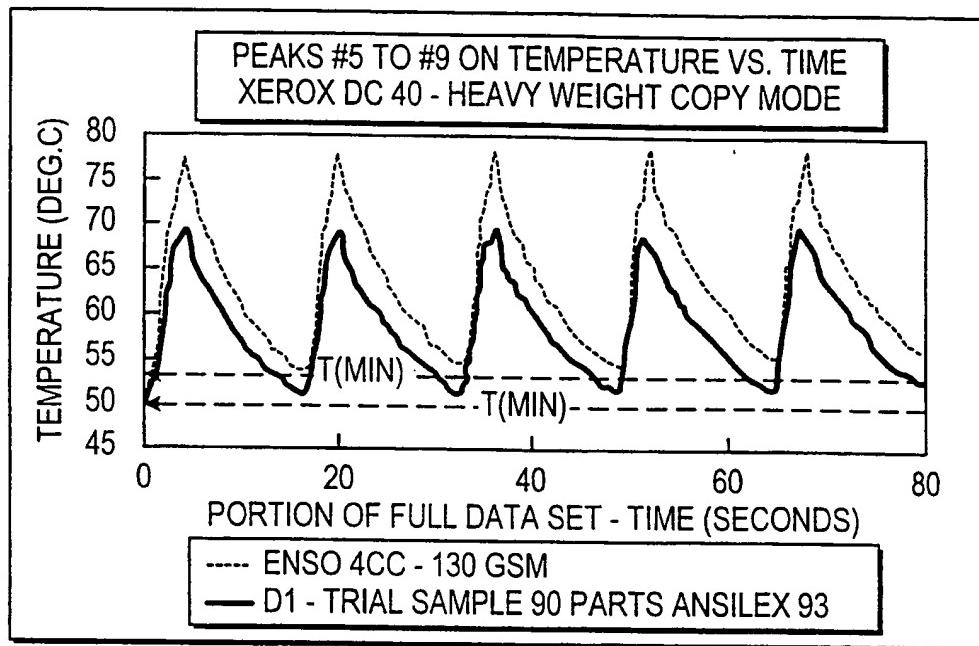


FIG. 3

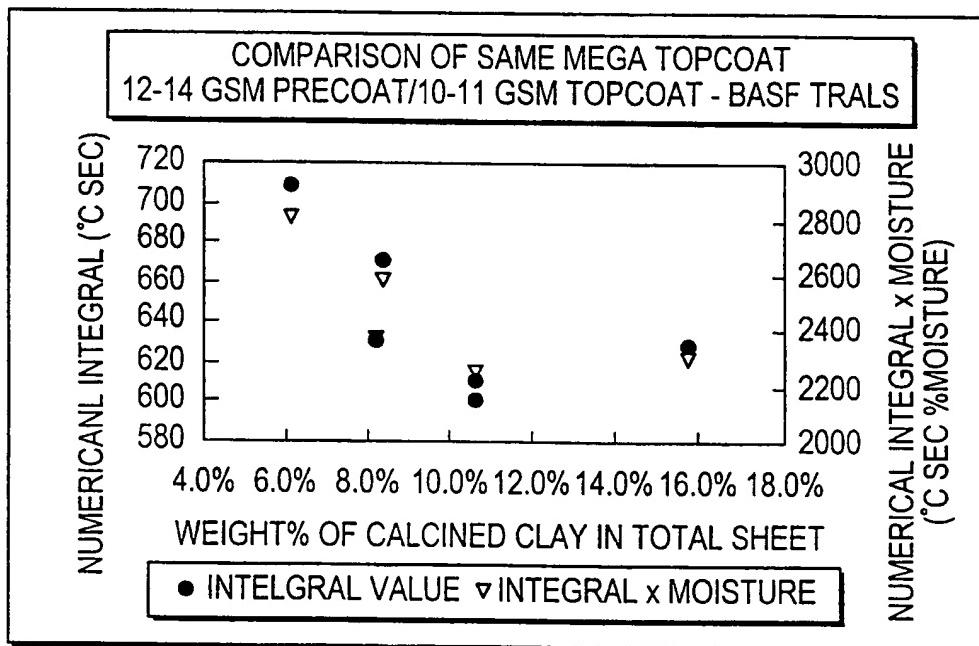


FIG. 4

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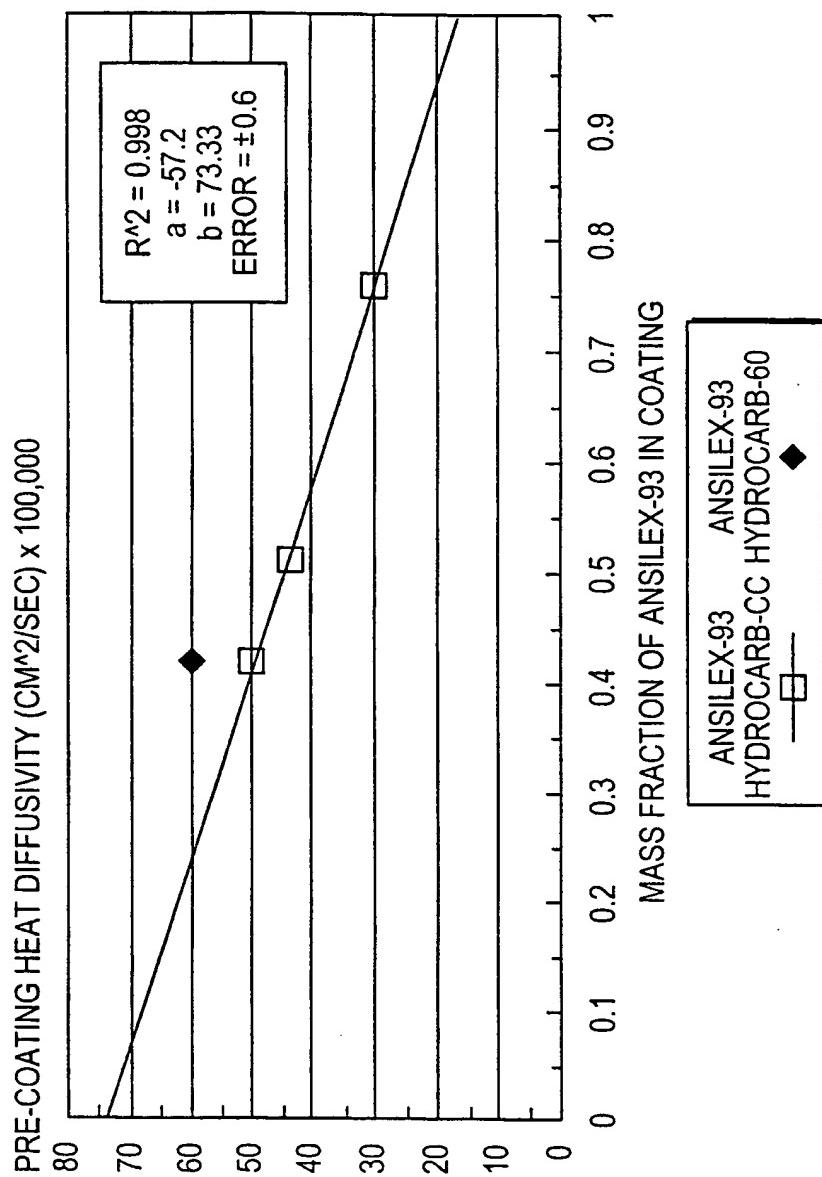


FIG. 5

FIG. 6A

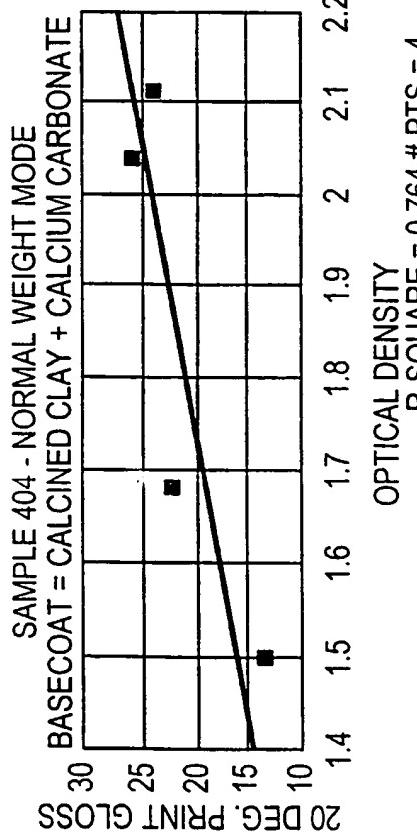


FIG. 6B

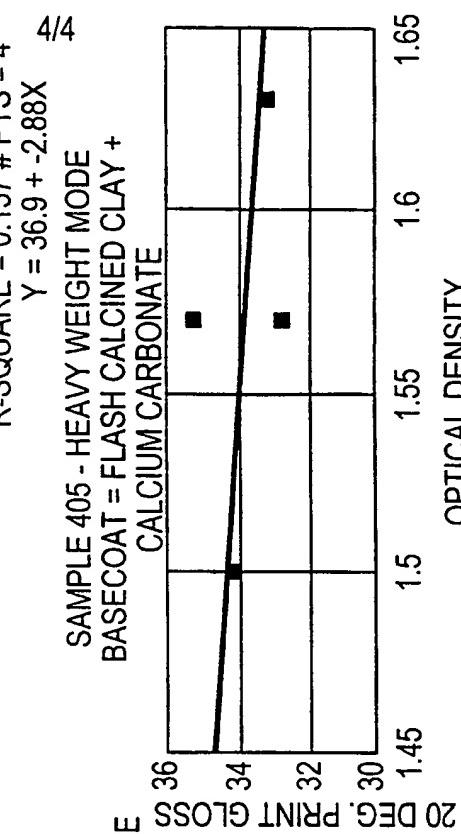
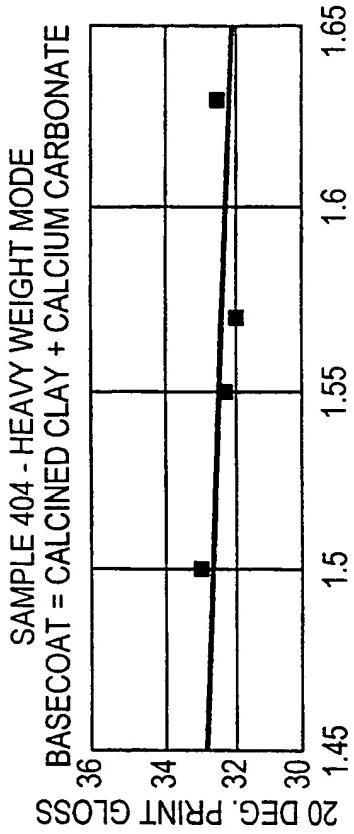


FIG. 6C



INTERNATIONAL SEARCH REPORT

International application No. PCT/US99/30817

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B41M 5/00, 5/40
US CL :428/206, 211, 212, 331

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/206, 211, 212, 331

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,377,612 (SERLIN et al.) 22 March 1983, see column 5, lines 35-38.	1-10

Further documents are listed in the continuation of Box C. See patent family annex.

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Date of the actual completion of the international search 17 MARCH 2000	Date of mailing of the international search report 31 MAR 2000
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